

## Claims

[c1] 1. A method for determining driving wheel torque for a vehicle having a hybrid electric powertrain, the powertrain comprising an engine, an electric motor, a battery, a generator and gearing that define plural torque flow paths from the engine and the motor to a torque output shaft, the method comprising:

calculating angular acceleration of the motor;

calculating angular acceleration of the engine;

calculating moments of inertia of the motor and the generator;

calculating static gearing output torque and motor torque; and

estimating total wheel torque as a function of operating variables including inertia of both the motor and the generator, angular acceleration of the engine, motor torque and torque ratio from the motor to the vehicle wheels.

[c2] 2. A method for determining driving wheel torque for a vehicle having a hybrid electric powertrain with a parallel operating mode, the powertrain comprising an engine, an electric motor, a battery, a generator and gearing that

define plural torque flow paths from the engine and the motor to a torque output shaft, the method comprising:  
calculating angular acceleration of the motor;  
calculating angular acceleration of the engine;  
calculating moments of inertia of the motor, the engine and the generator;  
calculating static gearing output torque and motor torque; and  
estimating total wheel torque as a function of operating variables including inertia of both the motor and the generator, angular acceleration of the engine, motor torque and torque ratio from the motor to the vehicle wheels.

[c3] 3. A method for determining driving wheel torque for a vehicle having a hybrid electric powertrain with a non-parallel operating mode, the powertrain comprising an engine, an electric motor, a battery, a generator and gearing that define plural torque flow paths from the engine and the motor to vehicle wheels, the method comprising:  
calculating angular acceleration of the motor;  
calculating angular acceleration of the engine;  
calculating moments of inertia of the motor and the generator;  
calculating static gearing output torque and motor

torque during operation in the non-parallel mode as a function of torque ratio from the generator to the motor and generator torque; and estimating total wheel torque as a function of operating variables including inertia of both the motor and the generator, angular acceleration of the engine, motor torque and torque ratio from the motor to the vehicle wheels.

- [c4] 4. A method for determining driving wheel torque for a vehicle having a hybrid electric powertrain with non-parallel and parallel operating modes, the powertrain comprising an engine, an electric motor, a battery, a generator and gearing that define plural torque flow paths from the engine and the motor to vehicle wheels, the method comprising:
  - calculating angular acceleration of the motor;
  - calculating angular acceleration of the engine;
  - calculating moments of inertia of the motor, the engine and the generator; and
  - calculating static gearing output torque during operation in the parallel mode as a function of operating variables including torque ratio from the generator to the motor, engine torque, engine moment of inertia and engine angular acceleration.

[c5] 5. The method set forth in claim 1 wherein estimated total wheel torque is computed in accordance with the equation:

$$T_{\text{total\_wheel}} = T_{\text{mot2wheel}} * (T_{\text{mot}} - T_{\text{p@mot}} + J_{\text{gen\_couple}} * \dot{\omega}_{\text{eng}} - J_{\text{mot\_eff}} * \dot{\omega}_{\text{eng}})$$

where:

$T_{\text{total\_wheel}}$  = total wheel torque estimate;

$T_{\text{mot2wheel}}$  = torque ratio from motor to wheels;

$T_{\text{p@mot}}$  = torque @ motor shaft;

$J_{\text{gen\_couple}}$  = coupled moment of inertia of generator and the gear element to which it is connected;

$\dot{\omega}_{\text{eng}}$  = engine angular acceleration;

$J_{\text{mot\_eff}}$  = sum of the lumped motor and gearing inertia and the lumped generator inertia reflected at the motor; and

$T_{\text{mot}}$  = motor torque.

[c6] 6. The method set forth in claim 2 wherein estimated total wheel torque is computed in accordance with the equation:

$$T_{\text{total\_wheel}} = T_{\text{mot2wheel}} * (T_{\text{mot}} - T_{\text{p@mot}} + J_{\text{gen\_couple}} * \dot{\omega}_{\text{eng}} - J_{\text{mot\_eff}} * \dot{\omega}_{\text{eng}})$$

where:

$T_{\text{total\_wheel}}$  = total wheel torque estimate;

$T_{\text{mot2wheel}}$  = torque ratio from motor to wheels;

$T_{\text{p@mot}}$  = torque @ motor shaft;

$J_{\text{gen\_couple}}$  = coupled moment of inertia of generator and the gear element to which it is connected;

$\dot{\omega}_{\text{eng}}$  = engine angular acceleration;

$J_{\text{mot\_eff}}$  = sum of the lumped motor and gearing inertia and the lumped generator inertia reflected at the motor; and

$T_{\text{mot}}$  = motor torque.

[c7] 7. The method set forth in claim 3 wherein estimated total wheel torque is computed in accordance with the equation:

$$T_{\text{total\_wheel}} = T_{\text{mot2wheel}} * (T_{\text{mot}} - T_{\text{p@mot}} + J_{\text{gen\_couple}} * \dot{\omega}_{\text{eng}} - J_{\text{mot\_eff}} * \dot{\omega}_{\text{eng}})$$

where:

$T_{\text{total\_wheel}}$  = total wheel torque estimate;

$T_{\text{mot2wheel}}$  = torque ratio from motor to wheels;

$T_{\text{p@mot}}$  = torque @ motor shaft;

$J_{\text{gen\_couple}}$  = coupled moment of inertia of generator and the gear element to which it is connected;

$\dot{\omega}_{\text{eng}}$  = engine angular acceleration;

$J_{\text{mot\_eff}}$  = sum of the lumped motor and gearing inertia and the lumped generator inertia reflected at the motor; and

$T_{\text{mot}}$  = motor torque.

[c8] 8. The method set forth in claim 3 wherein static gearing output torque is computed in accordance with the equa-

tion:

$$T_{p@mot} = T_{gen2mot} * T_{gen}$$

where:

$T_{p@mot}$  = torque at motor shaft;

$T_{gen2mot}$  = torque ratio from generator to motor shaft;

and

$T_{gen}$  = generator torque.

[c9] 9. The method set forth in claim 4 wherein static gearing output torque is computed in accordance with the equation:

$$T_{p@mot} = -T_{gen2mot} * (T_{eng} - J_{eng} * \text{dot}\omega_{eng})$$

where:

$T_{p@mot}$  = torque at motor shaft;

$T_{gen2mot}$  = torque ratio from engine to motor shaft;

$T_{eng}$  = engine torque;

$J_{eng}$  = lumped moment of inertia of engine and the element of the gearing to which it is connection; and

$\text{dot}\omega_{eng}$  = engine angular acceleration.